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AIR FORCE MISSILE DEVELOPMENT CENTER

TECHNICAL REPORT

THE MEASUREMENT OF CONCEPT FORMATION IN THE CHIMPANZEE AND ITS RELEVANCE TO THE STUDY OF BEHAVIOR IN SPACE ENVIRONMENTS

Frederick H. Rohles, Jr.
Richard E. Belleville
Marvin E. Grunzke

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July 1960

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AIR FORCE MISSILE DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
Holloman Air Force Base, New Mexico
July 1960

ABSTRACT

This report describes a new procedure for measuring higher intellectual processes in the chimpanzee. The fully automatic equipment employed eliminates continuous monitoring by the experimenter and can be modified readily for conducting similar research during space flight.

PUBLICATION REVIEW

This Technical Report has been reviewed and is hereby approved for publication.

FOR THE COMMANDER:

Rufus R. Hessberg Jr.

RUFUS R. HESSBERG, JR.
Lt Colonel, USAF (MC)
Chief, Aeromedical Field Laboratory

ACKNOWLEDGEMENTS

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CARE AND HANDLING OF THE SUBJECTS

The animal experimentation performed in this study was conducted in accordance with the "Rules Regarding Animals", established by The American Psychological Association and The American Medical Association.

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THE MEASUREMENT OF CONCEPT FORMATION IN THE CHIMPANZEE AND ITS RELEVANCE TO THE STUDY OF BEHAVIOR IN SPACE ENVIRONMENTS

I. INTRODUCTION

The adequacy and reliability of any life support system of a manned space vehicle is usually judged on the basis of its operation with infra-human subjects, and, in turn, judged to be safe for man if the animal subject suffers no deleterious physiological effects as a result of exposure to the environmental parameters afforded by the system. This has been the pattern for much of the experimentation on the environmental factors associated with space flight (Ref. 1). However, the value of the information derived from animals participating in these experiments can be greatly increased if behavioral measures are added to the standard physiological appraisal of the organism.

While the environmental insults imposed by orbital flight may prove disrupting to the animal's physiological processes, they may in no way affect its ability to perform a task in space that it has learned on the ground. Conversely, a decrement in performance is likely to occur during a period of apparent normal physiological functioning. Thus, by obtaining both behavioral and physiological data, a better estimate can be made of the over-all condition of the animal during actual and simulated space flight. This, in turn, will increase the reliability of the extrapolation to man when similarly exposed.

Released by authors 2 May 1960

Although laboratory methods for determining the physiological state of an animal are standardized and well known, this is not true of the techniques for assessing behavior. Thus, the question is raised concerning the types of behavioral measures that should be employed. And when oriented toward obtaining these measures during space flight, the answer must be considered, in part, in terms of the species involved, the time available, and equipment required for obtaining these measures.

These factors were among several considered in the complex avoidance task for chimpanzees described in an earlier report (Ref. 2). The purpose of this paper is to describe a second task for chimpanzees that is aimed toward measuring higher intellectual functioning during space flight.

II. METHODS

A. Subjects

Two female chimpanzees, Number 3 and Number 52, served as subjects. At the beginning of the study they weighed 67 and 51 pounds, respectively. These animals had served as subjects in physiological experiments; however, they had never participated in any behavioral investigations. Since the subjects were not born in captivity, their ages could not be determined accurately; however, on the basis of dental eruptions, it was estimated that subjects 3 and 52 were 10 and 4 years of age, respectively. Each subject was given a physical examination weekly.

B. Apparatus

Two identical steel chambers were used and served the dual purpose of living quarters and test chamber. Each subject remained in its respective chamber throughout the course of the investigation.

Each chamber was 37 inches long, 29 inches wide, and 51 inches high (interior dimensions) and was illuminated by a 25-watt houselight; an exhaust fan was mounted on top of the chamber. Three In-line Digital Displays* were mounted on the wall of the chamber so that the ground-glass projection surface was flush with the interior chamber wall. These displays were arranged in a horizontal row 21 inches above the chamber floor; the distance between displays was 2-3/4 inches. All displays were capable of presenting one of three white symbols on the one inch by one and one fourth inch black ground-glass surface; the symbols used in the present study were a circle, triangle, and square. A lever seven-eighths of an inch in diameter and extending 3-1/4 inches from the chamber wall was mounted 2-1/2 inches below each display. To the left of the displays and 14-1/2 inches above the chamber floor, was a hopper for receiving food pellets. These were delivered by an automatic pellet dispenser mounted on the exterior chamber wall above the hopper. The spherical food pellets which were specifically designed for use in this dispenser weighed 0.67 grams.** A photograph of the chamber is shown in Figure 1. Water was available <u>ad libitum</u> throughout the experiment.

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* The In-line Digital Display is manufactured by Industrial Electronic Engineers, Inc., 5528 Vineland Avenue, North Hollywood, California.

** The pellet dispenser is manufactured by Foringer and Co., Rockville, Maryland. The pellets are the product of Deitrich and Gambrill, Frederick, Maryland.

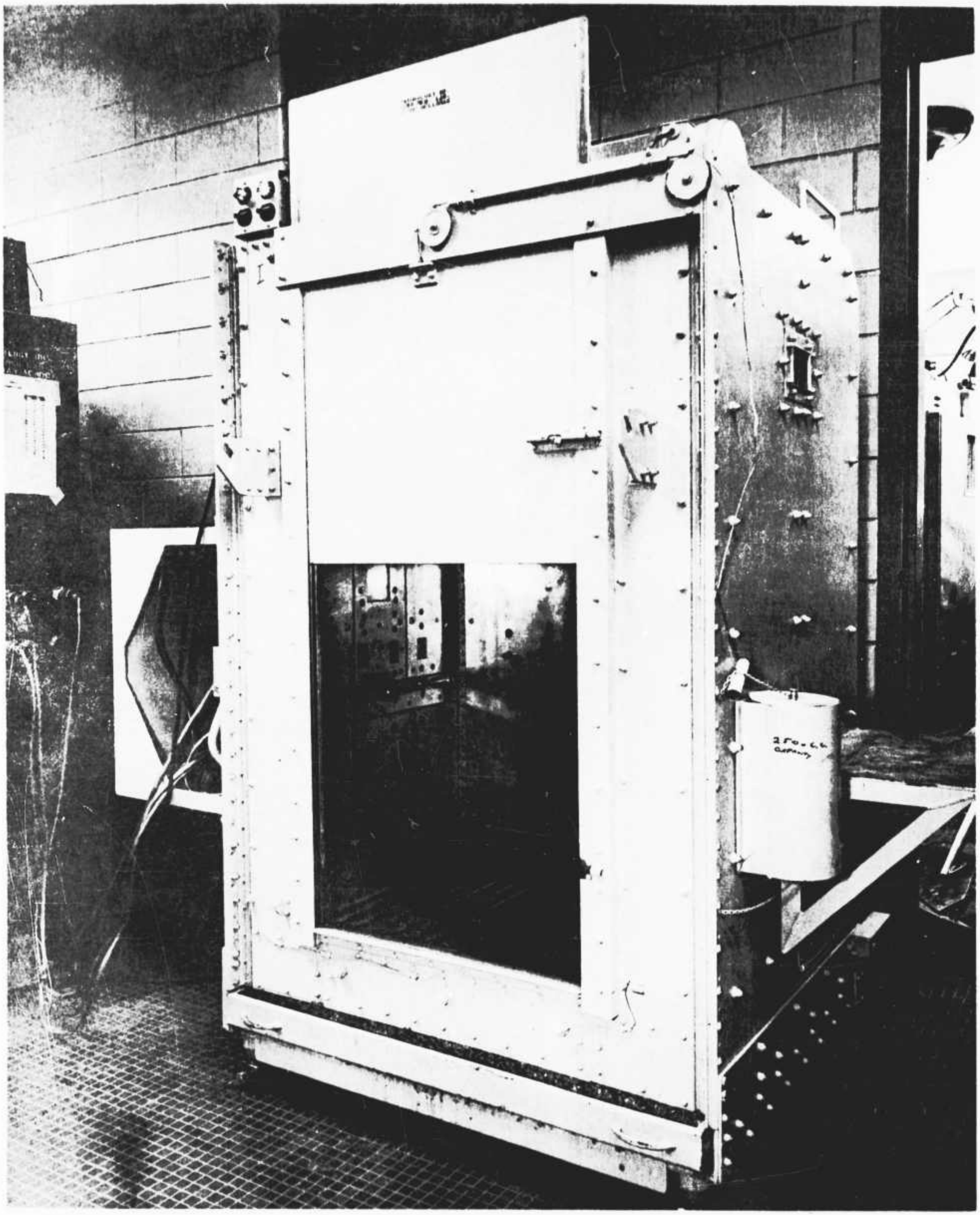

FIGURE 1. CHIMPANZEE TEST CHAMBER

Presentation of the symbols on the displays was accomplished automatically and 18 discrete steps were required in order for each of the three symbols to be "odd" with respect to the other two "like" or "distractor" symbols in all three display positions, the order of presentation is presented in Table I. Programming of the time between presentations, reward delivery, and response recording was accomplished with standard commercial operant conditioning equipment.

C. Procedure

Following a food deprivation period of 30 hours, each subject was placed in its chamber and magazine training was given for one day. This consisted of presenting an "odd" symbol without the distractors for five seconds. The display was then turned off and a food pellet was delivered into the hopper. The procedure was repeated at 60 second intervals. The symbols were presented in the order and display position shown in Table I. Using this procedure, subjects Number 3 and Number 52 received 97 and 103 pellets respectively.

For the next four days the arrangement of symbol presentation was the same as during the magazine training, however, the symbol remained illuminated until the subject pressed the lever under the display on which it appeared. When this response was made, a food pellet was delivered and the symbol for the next set was presented. Responses on either of the other two levers caused the symbol to disappear momentarily and then to reappear without moving to the next set. Each subject was allowed 450 food pellets per day.

TABLE I

ONE GROUP OF 18 STIMULUS SETS
IN ORDER OF PRESENTATION

STIMULUS SET	SYMBOL ON DISPLAY		
	1	2	3
1	○	△	○
2	△	△	○
3	○	○	□
4	△	○	○
5	△	○	△
6	□	□	△
7	○	□	□
8	△	□	□
9	△	△	□
10	□	○	□
11	□	△	△
12	○	□	○
13	○	○	△
14	○	△	△
15	△	□	△
16	□	○	○
17	□	△	□
18	□	□	○

Following this period, and throughout the remainder of the experiment, symbols were presented on all three displays as shown in Table I. When the lever was pressed under the display having the "odd" symbol, a pellet was delivered; two seconds later the next set was presented. When errors occurred, i.e. if either of the levers under the displays having "like" symbols was pressed, no reward was delivered and all displays were turned off for one minute; following this delay period, the same set of symbols was presented again.

A correct response was required for each set of symbols before the next set was presented. During the early stage of training each subject was given 25 groups of 18 stimulus sets daily; this amounted to 450 food pellets. Because it was observed that the accuracy of the discriminations appeared to diminish toward the end of the test session, the number of trials was reduced to 20 groups of 18 sets each. This, in turn, reduced the number of reinforcements to 360 per day. The experiment was terminated after 50 days when it became obvious that the subjects had reached their maximum performance level.

Performance levels were determined daily by the following ratio:

$$\text{Performance level} = \frac{\text{Total correct responses}}{\text{Total responses}}$$

III. RESULTS AND DISCUSSION

The oddity technique employed in this study has been used extensively with both animal and human subjects to measure concept formation (Ref. 3). Problems nearly identical to those used in this study are incorporated into the Revised Stanford-Binet Intelligence Test (Ref. 4) for children at the 4-1/2 year mental age level. This technique has also been used with monkeys (Ref. 5) and chimpanzees (Ref. 6). However, each of these investigations contains a procedure which precludes the employment of this task during space flight; an experimenter is required to present the stimuli, deliver rewards, and record responses. Needless to say, such a procedure could not be employed during space flight.

However, one of the most outstanding features of modern operant conditioning is the complete elimination of the experimenter variable (Ref. 7). The subject performs in a sound-attenuated chamber on different reinforcement schedules and is rewarded for its behavior by automatic devices capable of delivering either food pellets or liquid; likewise, programming and response recording is accomplished by automatic equipment; the only direct contact the experimenter has with the subject is when placing it in the experimental environment.

Taking this procedure as a starting point, the chamber described above was constructed. Utilizing the In-line Digital Display in conjunction with the commercial operant conditioning programming equipment and reinforcement devices, the necessity for the continuous presence of the experimenter was eliminated.

The results obtained with this procedure are shown in Figure 2. These data, which are typical of most acquisition curves, demonstrate that the task was learned in relatively short time and that the performance at the asymptotic portion of the curve was at a high level with little day-to-day variation. As stated previously, an incorrect lever press caused the displays to be turned off for one minute, and any responses during this period further delayed their appearance. During the early stages of training both subjects made a large number of responses in the absence of the stimulus; however, as the task was learned the number of these responses gradually diminished until no responses were made in the absence of the stimulus. With a more elaborate experimental design this procedure can be used for measuring higher intellectual functioning

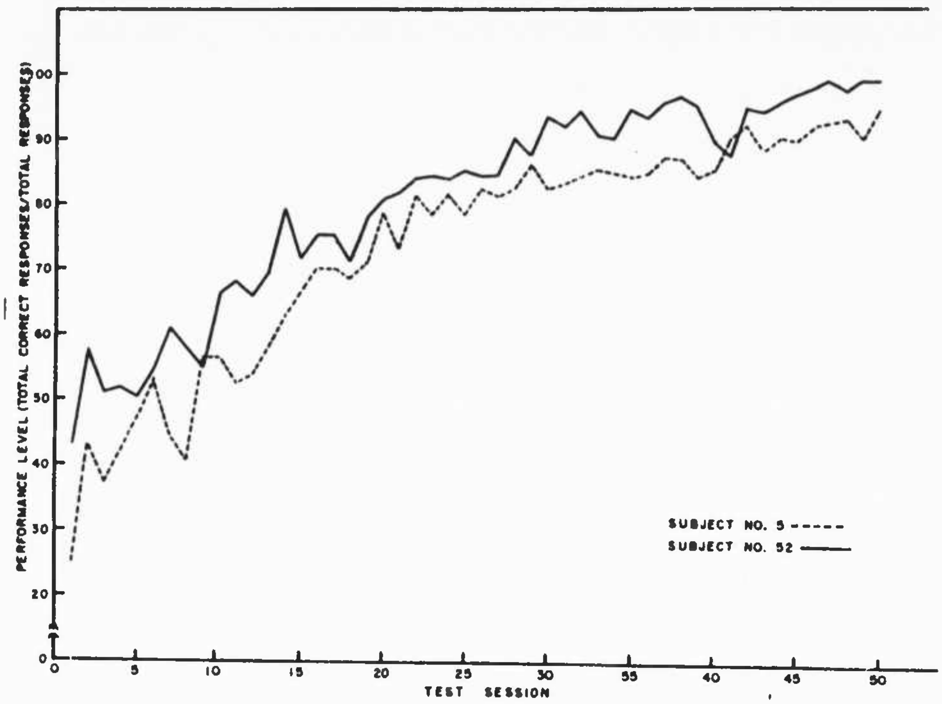

Figure 2. Acquisition of the Oddity Concept with Three Stimulus Variables

in animals during space flight. The problems of miniaturizing and transistorizing the programming equipment can be readily solved by engineers; a pellet dispenser that will operate during weightlessness is currently being tested in this laboratory, and the suppliers of the In-line Digital Displays have developed a smaller, more rugged unit which will withstand the environmental insults imposed by space flight.

Based upon observations following the experiment it was the opinion of the attending veterinarian that these subjects suffered no obvious prolonged adverse effects. The basic diet of food pellets was supplemented with two pieces of fruit daily, either an apple, orange, or banana and a 600-Calorie fluid supplement. Under this regimen subjects 3 and 52 lost seven and five pounds respectively, during the 50 day period. Aside from this, no adverse physical changes were observed.

In addition to the advantages stated previously, the procedures employed in this investigation are readily applicable to the laboratory study of higher intellectual functioning in primates. From this study and on the basis of those in progress it is apparent that the apparatus is capable of measuring the same factors as the Wisconsin General Test Apparatus (Ref. 8), a device that has been used as a standard for over 20 years. More important, it eliminates the time consuming requirement of the experimenter's presence. The speed of presenting the stimuli, delivering the reward and recording the results, permits a greater amount of experimentation in a shorter period of time.

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